Biological Evaluation of Hemlock Woolly Adelgid at New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River, West Virginia, March 2008

Prepared by

Karen Felton, Biologist
And
Bradley Onken, Entomologist
USDA Forest Service
State and Private Forestry
Forest Health Protection
180 Canfield Street
Morgantown, WV 26505

ABSTRACT

In the winter of 2008, USDA Forest Service personnel conducted surveys to evaluate hemlock woolly adelgid (HWA), *Adelges tsugae* population densities and to assess the need for treatment at the New River Gorge National River (NERI), the Gauley River National Recreation Area (GARI), and the Bluestone National Scenic River (BLUE). Current populations are sufficient in most areas to impact tree health. Treatments using imidacloprid on accessible, individual, high-valued, infested hemlock trees and the release of natural enemies are recommended in the Burnwood, Fern Creek, upper Wolf Creek, Kaymoor, South Nuttall, Grandview, and Kates Branch areas of NERI, Hedricks Creek area of GARI, and on the west side of Bluestone River downriver of the Mountain Creek Lodge of BLUE.

INTRODUCTION

HEMLOCK WOOLLY ADELGID

Adelgids are small, soft-bodied insects that feed exclusively on conifers. The family is divided into two genera: *Adelges* and *Pineus*. There are six species of *Adelges* that occur in North America, of which only one is native (Montgomery 1999), the Cooley spruce gall aphid (*Adelges cooleyi*). This adelgid occurs coast to coast in northern North America. Its primary hosts are recorded as white (*Picea glauca*), blue (*Picea pungens*), Sitka (*Picea sitchensis*), and Engelmann (*Picea engelmannii*) spruce (Baker 1972). It has an alternate host, Douglas fir (*Pseudotsuga menziesii*). There are 10 species of *Pineus* that occur in North America, of which seven are native. Four of these the pine bark adelgid (*Pineus strobi*); the pine leaf adelgid (*P. pinifoliae)*; the red spruce adelgid (*P. floccus*); and the spruce gall adelgid (*P. similes*) seem to be indigenous to eastern North America (Drooz 1989, Montgomery 1999). These species attack eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and black spruce (*Picea mariana*) but seldom cause extensive damage (Drooz 1989, Montgomery 1999). Little is known about the population dynamics, ecological role, or the predator complex associated with these native adelgids.

Native to Japan, the hemlock woolly adelgid (*Adelges tsugae)* is a pest of eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliana*) (Onken et al. 1999), both of which are considered highly susceptible to the adelgid, with no documented resistance (Bentz et al. 2002). The latter tree species is found only in the southern region of the Appalachian Mountains (Onken et al. 1999). HWA is currently established in 17 eastern states from Georgia to Maine, and tree decline and mortality have increased at an accelerated rate since the late 1980s. For example, in the Shenandoah National Park (SNP), hemlock crown health has declined since the early 1990s. In 1990, greater than 77 percent of the hemlocks sampled were in a "healthy" condition; by 1998, less than 10 percent were in a "healthy" condition (Akerson and Hunt 1998). In another study at

quantity of the food source, which is associated with the decline in health and vigor of the host tree (McClure 1996, Onken et al. 1999).

Adelgid feeding can kill a mature tree in about 5 to 7 years (McClure et al. 2001). This tiny insect (~ 1 mm) feeds on all size classes of hemlock, from seedling to mature, old growth tree. The first instar nymphs, called crawlers, search for suitable sites at the base of the hemlock needles, and insert their feeding stylets into the young hemlock twigs. Once settled the adelgid is committed to that feeding site throughout the remainder of its development. The mouth parts of the adelgid, the stylet bundle, is more than three times the length of the insect and penetrates deep within the plant tissues. HWA does not deplete nutrients directly by feeding on the sap, but rather by depleting the food reserves from the tree's storage cells (McClure et al. 2001). These food reserves are necessary for the production of new growth in the following year.

Dispersal and movement of HWA during its egg and mobile first instar stages is associated with wind, birds, deer, and other forest dwelling mammals. Humans also move the adelgid during logging and recreational activities and movement of infested nursery stock (McClure 1995). Natural enemies native to eastern North America are not capable of maintaining low-level HWA populations (Van Driesche et al. 1996, Wallace and Hain 1998).

HWA was first reported in the western U.S. in the 1920s (Annand 1924, McClure 2001). HWA populations on western tree species, including western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. mertensiana*), appear to be innocuous; these tree species are believed to be resistant because little damage has been reported (McClure 2001). Unfortunately, both these trees are of limited value for hybridization and planting due to their poor adaptation to the east coast environment (Bentz et al. 2002). In the East, HWA was first reported in 1951 near Richmond, Virginia. It was considered to be more of an urban landscape pest and was controlled using a variety of insecticides applied with ground spraying equipment. Observations of the adelgid were periodically reported in several Mid-Atlantic States in the 1960s and 1970s but it was not until the 1980s that HWA populations began to surge and spread northward to New England at an alarming rate. By the late 1980s to early 1990s, infestations of HWA were reported to be causing extensive hemlock decline and tree mortality in hemlock forests throughout the East (McClure 2001).

Recent phylogenetic analyses now suggests that HWA in eastern North America likely originated from southern Japan while HWA found in western North America represents a separate lineage (Havill etal. 2006). The standing theory is that HWA found in western North America is native to that region and western hemlocks have co-evolved with this pest. This theory is further supported when we consider that at least one host specific natural enemy, *Laricobious nigrinus*, is also only found in western North America.

HEMLOCK IMPORTANCE

Eastern hemlock is an extremely shade tolerant tree species, capable of surviving for as long as 350 years underneath a shaded forest canopy (Quimby, 1996). It is a slow-

- Educate the visiting public and neighbors about HWA and the threat to the hemlock forest through a variety of media including newspapers, television, internet, and park sponsored interpretive programs.

- Inventory and monitor long-term trends within the hemlock ecosystems, and document the effects of HWA on biological diversity and hemlock decline.

- Implement a suite of integrated pest management alternatives to mitigate the effects of HWA on the ecosystem including the use of biological and chemical controls.

- Continue to encourage and support research efforts to increase the knowledge and understanding of the ecological significance of the native hemlock forests.

The objectives of the suppression program are:

- Protect public health and safety in areas of the park with high visitor use, such as, picnic areas, overlooks, campgrounds, roads, and trail heads, through the reduction of hazardous trees created by the dead and dying hemlock trees.

- Preserve hemlock stands with large numbers of sensitive species where treatments are economically feasible and accessible to the public. Select a few exemplary hemlock stands and try to protect them in perpetuity.

- Protect federally protected species, hemlocks along high quality streams, and old growth forests where feasible.

Figure 3. John Perez, Biologist from NERI releasing *Scymnus sinuanodulus* beetles in May 2007.

Biological Control: Since 2005, the park, with assistance from the USDA Forest Service in Morgantown, WV, has been releasing predatory beetles in hemlock forests that contain outstanding resource values and located in areas inaccessible or impractical for chemical treatments. The releases have included *Laricobius nigrinus*, *Sasajiscymnus tsugae*, and *Scymnus sinuanodulus* predatory beetles (Table 1). Monitoring of the beetle release effort has been conducted by the US Forest Service and *Laricobius nigrinus* has been confirmed to be established at the Hedrick's Creek release sites.

Figure 4. *Laricobius nigrinus* beetle recovered at Hedrick's Creek in Fall 2006.

SURVEY AREAS

Survey areas at the parks were chosen by NPS resource management staff based on ecological significance and/or visual importance. Hemlock at NERI is an important component of the forest canopy on about 5,990 acres (about 7%) of the total park acreage. The seven areas at NERI surveyed included Burnwood Area, Fern Creek, upper Wolf Creek, Kaymoor Mine Trail, South Nuttall, Grandview, Kates Branch, and Glade Creek.

Burnwood is a 100 acre day use area located across from the Canyon Rim Visitor Center. This area is utilized for educational school trips and is the location of the Laing Loop Nature Trail.

Fern Creek has one of the more dense hemlock stands at NERI. The Endless Wall Trail, located in the Fern Creek area, is 2.4 miles long providing great views of the New River Gorge, and access to some of the best known climbing locations in the parks. A large portion of the stand is within a riparian zone. Breeding populations of the Swainson's warblers have been documented at Fern Creek, and the rare green salamander is known to occur there as well.

At Wolf Creek, hemlock trees are a dominant component of the forest and many trees range between 80 and 195 years old. Breeding populations of the rare Cerulan and Swainson's warbler, along with rare amphibians and the Allegheny woodrat occur in this area.

The Kaymoor area has a hiking trail that descends steeply to the abandoned Kaymoor Mine and provides a great overlook of the river and gorge. The South Nuttall area is upriver of the Kaymoor area.

Grandview has four developed overlooks with outstanding vistas and has a high visitor use. There are five trails ranging from 3/8 to 2 ½ miles in length. Hemlocks frame the vistas and are a major component of the rare rimrock forest community in this area. The rare Allegheny woodrat has been documented within the hemlock forests.

The Kates Branch area borders the largest wetlands complex (approximately 20 acres) at NERI. Hemlocks contribute to the ecological integrity of this wetland and the Kates Plateau Trail follows an old logging road through this area.

At Glade Creek there is a 5.6 mile trail that follows an abandoned railroad. The creek has good to excellent water quality and a diverse ecosystem. The area is known for its waterfalls and as a popular trout stream.

Hemlock stands at GARI are an important component of the forest canopy on about 4,000 acres (about 35% of the total park acreage). The GARI contains hemlock stands designated as "Outstanding Natural Feature" having "high intrinsic or unique values" in the park's General Management Plan (1997). The area surveyed for HWA populations at

Severe Decline (SD) = more than 50% of the crown with branch mortality, dieback, discoloration or leaf dwarfing, but foliage still present indicating that the tree is alive

A GPS (global positioning system) unit was used to collect coordinates (decimal degrees, WGS84) and map the area surveyed within each park. A GPS point represented the general area of each stand.

RESULTS

A total of nine areas were surveyed within NERI, GARI, and BLUE: Burnwood area, Fern Creek, upper Wolf Creek, Kaymoor area, South Nuttall, Grandview, Kate's Branch, Glade Creek, Hedricks Creek, and Bluestone River. Inclement weather prevented the crew from surveying Glade Creek. This area will be surveyed later in the spring to determine the HWA populations and the need for treatment in this area. The survey areas are represented in Figures 7a-b, and a summary of the results is presented in Table 2.

All survey areas reached a STOP threshold of eight trees within the first block of the stand, indicating nearly all hemlock trees are infested with some level of HWA densities. Stand level infestations ranged from 47 -100 percent. HWA densities within tree were observed to range from none to moderate among the survey areas.

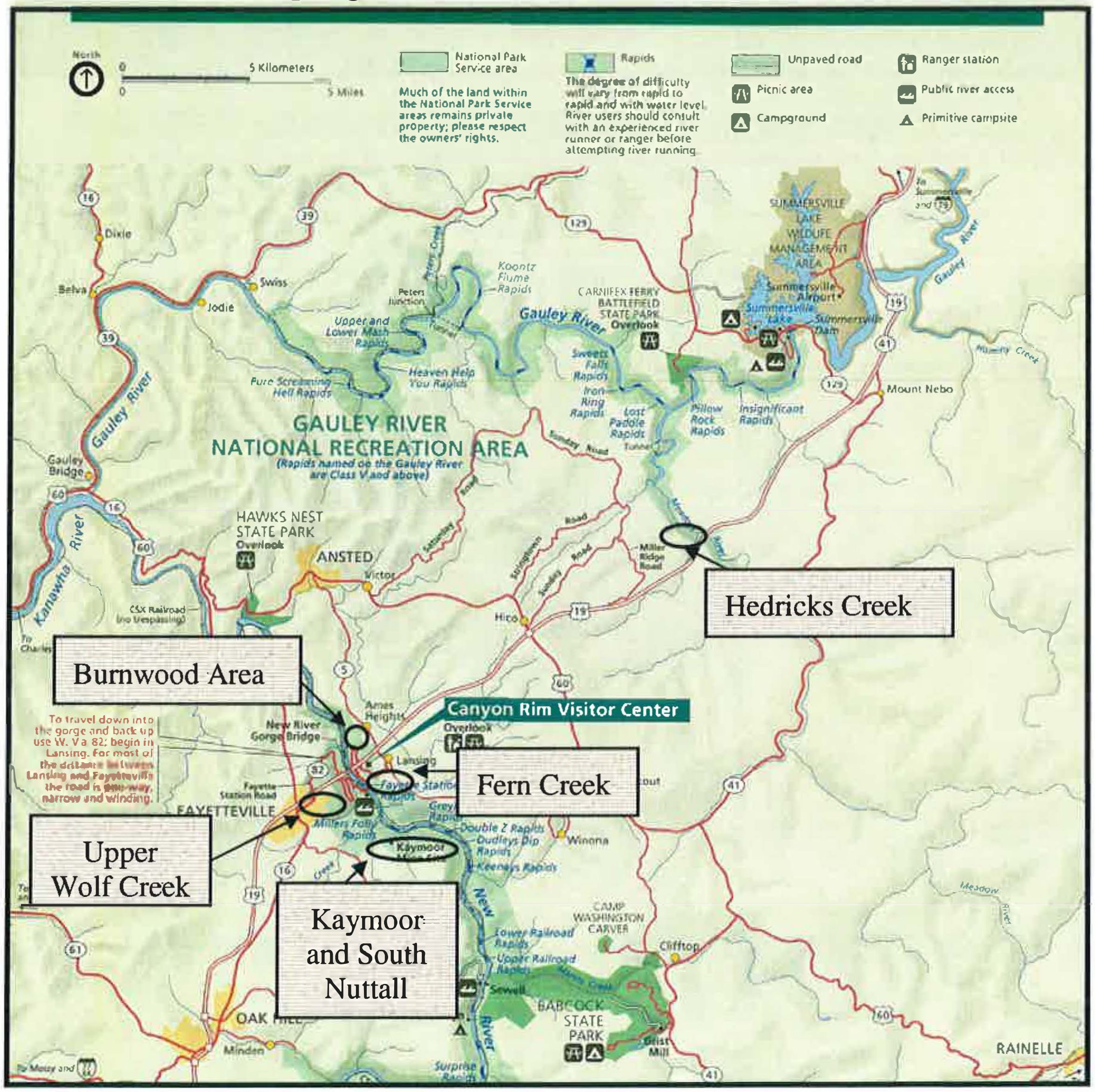
In general hemlock conditions range from healthy to light decline within most of the survey areas, with exception of Bluestone River, where decline symptoms are more prevalent and range from light to severe decline.

Table 2. Summary of HWA survey data collected in winter/spring, 2008 at NERI, GARI, and BLUE.

Location	Number of Trees Surveyed	Stand Level Infestation (%)[1]	Tree Level Infestation Range[2]
Burnwood Area (NERI)	8	100	L-M
Fern Creek (NERI)	14	57	N-M
Wolf Creek (NERI)	8	100	L-M
Kaymoor (NERI)	9	89	N-M
Grandview (NERI)	13	62	N-L
Kate's Branch (NERI)	17	47	N-L
Hedricks Creek (GARI)	12	67	N-M
Bluestone (BLUE)	11	73	N-M
South Nuttall (NERI)	8	100	L-M

[1]HWA stand level infestation percentage = STOP threshold (8 trees)/ number of trees surveyed

Figure 7a. Hemlock woolly adelgid survey locations at New River Gorge National River, the Gauley River National Recreation Area, and the Bluestone National Scenic River, winter/spring, 2008.



DISCUSSION

HWA populations are generally low to moderate throughout most of the survey areas. HWA densities are highly variable between trees, ranging from none to moderate, but all sites have an established population. Predicting year to year changes in HWA densities is difficult because of the dynamic nature of the many variables involved. Factors such as future climatic conditions, changing micro habitat (tree and site) conditions and other biotic and abiotic factors affect both survival and fecundity of HWA. However the pattern of abundance and distribution is conducive to outbreak populations when conditions are favorable. Consequently, impacts to hemlock resources throughout NERI, GARE, and BLUE will continue to increase.

MANAGEMENT CONSIDERATIONS

Chemical management options for protecting hemlock stands are limited by the biology and feeding behavior of HWA, pest population densities, site conditions (i.e. proximity to streams), accessibility and limited application technology currently available. Insecticide treatments although effective, are conducted on an individual tree basis which can be both labor intensive and costly. Thus treatment strategies are typically focused in high value sites such as recreational or scenic areas or where hemlock stands have an important ecological role or genetic preservation is a high priority. Classical biological controls such as predators and pathogens are being pursued by the USDA Forest Service but will likely take years to become effectively established. As such, preservation of hemlocks in the short term will require intensive monitoring and periodic chemical treatments when infestations are discovered.

Foliar Chemical Treatments: Aerial spray using horticultural oil or insecticidal soap is not an option because aerial sprays could not provide the needed "saturation" necessary to ensure that the insecticide adequately covers the insect. Aerial spraying with more toxic insecticides (e.g. malathion or diazinon) would have very significant, unacceptable impacts on a wide range of non-target insects and other animals and limited control benefits (Evans 2000). Application of insecticides using ground spraying equipment is generally limited to areas accessible to hydraulic spray equipment and areas where over spray or run off would not contaminate streams, lakes or ponds. Backpack sprayers could be effectively used for foliar treatment of infested seedlings and saplings to protect regeneration.

Systemic Insecticides: Several systemic insecticides are labeled for adelgids and can be injected (e.g. imidacloprid, bidrin or Metasystox-R®) or implanted (e.g. acephate) into hemlock trees. Imidacloprid is by far the most common systemic insecticide being used to control HWA and is applied as a soil drench or injected into to the soil around hemlock trees. These insecticides are absorbed and trans-located by the vascular system of the tree to feeding adelgids and will effectively suppress HWA populations (Doccola et al. 2003, Webb et al. 2003, Evans 2000, Steward and Horner 1994, McClure 1992a). Soil injection in sandy or saturated soils should be avoided as leaching of imidacloprid into the soil profile and groundwater (McAvoy et al. 2002) is a possibility. Soil injections

years (Tater et al. 1998, Silcox 2002). The soil injection or soil drench methods of imidacloprid treatments can take several months for translocation to occur but typically has provided better consistency in treatment efficacy and is expected to provide control for at least 3 years. Stem injections should not be used on severely stressed trees.

Biological Control: There are no known parasites of adelgids. There are three predatory beetles approved for release and each is unique in its dispersal, reproductive potential, feeding behavior, and suitable climate regimes. They are all very host specific. Where these natural enemies are released is the responsibility of state forest health specialists from each state and the USFS. All of the releases are in infested hemlock stands found primarily along the leading edge of the generally infested area, where hemlocks are still healthy and HWA densities have not yet overwhelmed the trees. The release and establishment of HWA natural enemies is not likely to provide short term control of HWA. It is considered to be a long term approach and will likely require a complex of natural enemies to maintain HWA below damaging levels. It may be years before these predators can self perpetuate sufficiently before any level of success can be determined.

The first predator beetle to be imported and released for biological control is a tiny, black lady beetle, *Sasajiscymnus tsugae*, from Japan. Since 1995, over 2 million *S. tsugae* beetles have been released in over 200 sites in 16 eastern states from Georgia to Maine. The recovery of *S. tsugae* beetles in the years following release have been sporadic. The number of beetles recovered have rarely been more than one or two per site. Adult beetles have been captured near some of the release sites more than 6 years after release, and some more than 1/2 a mile from nearest release site.

Figure 8. Beetles released for biocontrol (left to right): *Sasjiscymnus tsugae* from Japan, *Scymnus sinuanodulus* from China and *Laricobius nigrinus* from Pacific Northwest.

Another predatory beetle, *Scymnus sinuanodulus*, a lady beetle from China, has been released since 2005. More than 36,000 adult beetles have been released in eight states. So far, few beetles have been recovered from the release sites.

A Derodontid beetle, *Laricobius nigrinus*, from the Pacific Northwest is also approved for release. Mass rearing of this predatory beetle began in 2003, and more than 45,000 beetles have been released in eleven states. Recovery of *L. nigrinus* has been confirmed at most sites. At some release sites, adult beetles are easily found and hundreds of larvae have been recovered.

Release of predator beetles should not take place in close proximity of hemlock trees that have received imidacloprid treatments. Preferred release sites are newly infested sites where trees and adelgids are still healthy. Older infested sites where adelgid densities are low and recovery of hemlock trees is evident has also proven acceptable. Predator beetles are laboratory reared and the number of predators available in any given year is variable depending in part, on the success of the rearing facilities to locate good quality host material for a food source. Artificial diets are not yet available.

Resource managers should continue to annually monitor tree health conditions, adelgid population densities and treatment efficacy. It is not logistically or economically feasible to chemically treat all trees in numerous or large hemlock stands. Therefore, resource managers must prioritize treatment areas and select individual, accessible, high valued, infested hemlock trees for treatment.

Predatory beetle releases take place in the spring or fall of the year when HWA are actively feeding. The establishment of these natural enemies offers potential long-term control and may minimize the need for repeated chemical treatments in future years. The release of HWA natural enemies within the park should continue.

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United States Department of Agriculture
Northeastern Area State and Private Forestry
180 Canfield Street
Morgantown, WV 26505-3101

Date: 3400
File Code: April 2, 2008

Calvin F. Hite, Superintendent
New River Gorge National River
USDI National Park Service
PO Box 246
104 Main Street
Glen Jean, WV 25846-0246

Dear Mr. Hite:

Enclosed is a biological evaluation of hemlock woolly adelgid (HWA) at New River Gorge National River (NERI), Gauley River National River (GARI), and Bluestone National Scenic River (BLUE). A total of nine areas were surveyed including portions of the Bluestone River at BLUE, Hedrick's Creek at GARI, and Burnwood Area, Fern Creek, upper Wolf Creek, Kaymoor, South Nuttall, Grandview, and Kates Branch areas at NERI.

In brief, all surveyed sites have established HWA populations although densities are variable within all three parks.

We recommend chemical treatment using imidacloprid via. soil or stem injections as appropriate on accessible, high-valued individual hemlock trees, based on the management objectives of the parks. In less accessible hemlock stands we encourage the release of HWA natural enemies, as they become available.

Please contact Brad Onken (304)285-1546 or Karen Felton (304)285-1556, if you have any questions concerning this report.

Sincerely,

Bob Lueckel
ROBERT G. LUECKEL
Field Representative MFO

Enclosure

Cc: John Perez, Biologist, NERI
Linda Drees, NPS, IPM Program Coordinator
Jerry Boughton, AO
Clark Haynes, WV
Rick Turcotte, FHP, MO √
Randy Dye, WV Div of Forestry
Glen Juergens, Monongahela NF